

1           **ANTI-SPLAY MEDICAL IMPLANT CLOSURE WITH**  
2           **CENTRAL MULTI-SURFACE INSERTION AND REMOVAL APERTURE**

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4           Cross-Reference to Related Application

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6           This is a continuation-in-part of co-pending U.S.  
7 Patent Application, Serial No.10/236,123 filed September 6,  
8 2002 for HELICAL WOUND MECHANICALLY INTERLOCKING MATING  
9 GUIDE AND ADVANCEMENT STRUCTURE, which is now U.S. Patent  
10 No. \_\_, \_\_, \_\_.

11  
12           Background of the Invention

13  
14           The present invention is directed to a closure for use  
15 in closing between spaced arms of a medical implant and  
16 securing a rod to the implant. In particular, the closure  
17 includes a non-circular multi-surfaced or multi-lobular  
18 internal bore for improved engagement by a complementary  
19 shaped tool for purposes of insertion and removal, and an  
20 interlocking helical guide and advancement structure that  
21 prevents splaying of upper ends of walls of the implant

1 within which the closure is placed away from an axis of  
2 rotation of the closure.

3 Medical implants present a number of problems to both  
4 surgeons installing implants and to engineers designing  
5 them. It is always desirable to have an implant that is  
6 strong and unlikely to fail or break during usage. It is  
7 also desirable for the implant to be as small and  
8 lightweight as possible so that it is less intrusive on the  
9 patient. These are normally conflicting goals and often  
10 difficult to resolve.

11 One particular type of implant presents special  
12 problems. In particular, spinal bone screws, hooks, etc.  
13 are used in many types of back surgery for repair of injury,  
14 disease or congenital defect. For example, spinal bone  
15 screws of this type are designed to have one end that  
16 inserts threadably into a vertebra and a head at an opposite  
17 end. The head is designed to receive a rod or rod-like  
18 member in a channel in the head in which the rod is both  
19 captured and locked to prevent relative movement between the  
20 various elements subsequent to installation. The channel in  
21 the head is open ended and the rod is simply laid in the  
22 open channel. The channel is then closed with a closure  
23 member. The open headed bone screws and related devices are

1 much easier to use and in some situations must be used  
2 instead of closed headed devices.

3 While open headed devices are often necessary and often  
4 preferred for usage, there is a significant problem  
5 associated with them. In particular, the open headed  
6 devices conventionally have two upstanding arms that are on  
7 opposite sides of a channel that receives the rod member.  
8 The top of the channel is closed by a closure after the rod  
9 member is placed in the channel. The closure can be of a  
10 slide in type, but such are not easy to use. Threaded nuts  
11 are sometimes used that go around the outside of the arms.  
12 Such nuts prevent splaying of the arms, but nuts  
13 substantially increase the size and profile of the implant  
14 which are not desirable. Many open headed implants are  
15 closed by plugs, bodies or closures that screw into threads  
16 between the arms, because such have a low profile. However,  
17 threaded plugs have encountered problems also in that they  
18 produce radially outward directed forces that lead to  
19 splaying or spreading of the tops of the arms or at least do  
20 not prevent splaying caused by outside forces that in turn  
21 loosen the implant. In particular, in order to lock the rod  
22 member in place, a significant force must be exerted on the  
23 relatively small plug. The tightening forces are required  
24 to provide enough torque to insure that the rod member is

1 clamped or locked in place relative to the bone screw, so  
2 that the rod does not move axially or rotationally therein.  
3 Torques on the order of 100 inch-pounds are typical.

4 Because open headed implants such as bone screws, hooks  
5 and the like are relatively small, the arms that extend  
6 upwardly at the head can rotate relative to the base that  
7 holds the arms so that the tops of the arms are rotated or  
8 bent outward relatively easily by radially outward directed  
9 forces due to the application of substantial forces required  
10 to secure the rod member. Historically, early closures were  
11 simple plugs that were threaded with V-shaped threads and  
12 screwed into mating threads on the inside of each of the  
13 arms. But, as noted above, conventional V-shaped threaded  
14 plugs tend to splay or push the arms radially outward upon  
15 the application of a significant amount of torque, which  
16 ends up bending the arms sufficiently to allow the threads  
17 to loosen or disengage and the closure to fail. To counter  
18 outward directed application of forces, various engineering  
19 techniques were applied to resist the spreading forces. For  
20 example, the arms were significantly strengthened by  
21 substantially increasing the width of the arms. This had  
22 the unfortunate effect of substantially increasing the  
23 weight and the profile of the implant, which was  
24 undesirable.

1       The tendency of the open headed bone screw to splay is  
2 a result of the geometry or contour of the threads typically  
3 employed in such devices. In the past, most bone screw head  
4 receptacles and screw plugs have employed V-shaped threads.  
5 V-threads have leading and trailing sides oriented at angles  
6 to the screw axis. Thus, torque on the plug is translated  
7 to the bone screw head at least partially in an axial  
8 outward direction, tending to push or splay the arms of the  
9 bone screw head radially outward. This in turn spreads the  
10 internally threaded receptacle away from the thread axis so  
11 as to loosen the plug in the receptacle. The threads also  
12 have smooth or linear surfaces in a radial direction that  
13 allow slippage along the surfaces since they at best fit  
14 interferingly with respect to each other and have in the  
15 past not interlocked together. Thus, forces other than  
16 insertion forces can act to easily splay the arms since the  
17 surfaces slide rather than interlock.

18       The radial expansion problem of V-threads due to the  
19 radial outward component of forces applied to a V-thread has  
20 been recognized in various types of threaded joints. To  
21 overcome this problem, so-called "buttress" threadforms were  
22 developed. In a buttress thread, the trailing or thrust  
23 surface is oriented perpendicular to the thread axis, while  
24 the leading or clearance surface remains angled. This

1 theoretically results in no radially inward or outward  
2 directed forces of a threaded receptacle in reaction to  
3 application of torque on the threaded plug. However, the  
4 linear surfaces still allow sideways slippage, if other  
5 forces are applied to the arms.

6       Development of threadforms proceeded from buttress  
7 threadforms, which in theory have a neutral radial force  
8 effect on the screw receptacle, to reverse angled  
9 threadforms, which theoretically positively draw the threads  
10 of the receptacle radially inward toward the thread axis  
11 when the plug is torqued. In a reverse angle threadform,  
12 the trailing side of the external thread is angled toward  
13 the thread axis instead of away from the thread axis, as in  
14 conventional V-threads. While buttress and reverse  
15 threadforms reduce the tendency to splay, the surfaces are  
16 not interlocking and the arms can still be bent outward by  
17 forces acting on the implant. The threads can be distorted  
18 or bent by forces exerted during installation. Therefore,  
19 while these types of threadforms are designed to not exert  
20 radial forces during installation, at most such threadforms  
21 provide an interference or frictional fit and do not  
22 positively lock the arms in place relative to the closure  
23 plug.

1        Furthermore, it is noted that plugs of this type that  
2        use threadforms are often cross threaded. That is, as the  
3        surgeon tries to start the threaded plug into the threaded  
4        receiver, the thread on the plug is inadvertently started in  
5        the wrong turn or pass of the thread on one arm. This  
6        problem especially occurs because the parts are very small  
7        and hard to handle. When cross threading occurs, the plug  
8        will often screw part way in the receiver and then "lock up"  
9        so that the surgeon is led to believe that the plug is  
10       properly set. However, the rod is not secure relative to  
11       the bone screw or other implant and the implant fails to  
12       function properly. Therefore, it is also desirable to have  
13       a closure that resists cross threading in the receiver.

14       As stated above, it is desirable for medical implants  
15       to have strong and secure elements which are also very  
16       lightweight and low profile so that the overall implant  
17       impacts as little as possible upon the patient. However,  
18       strong and secure are somewhat divergent goals from the  
19       goals of lightweight and low profile. Thus, size, weight,  
20       and profile must all be taken into consideration and  
21       minimized, as much as possible, consistent with effective  
22       functioning.

23       In order to provide sufficient strength and friction to  
24       resist movement of the various elements once the closure

1 plug is seated, it is necessary to apply a fairly  
2 substantial amount of torque to the closure.

3

#### 4 Summary of the Invention

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6 The present invention provides a closure for use  
7 particularly with an open-headed bone implant screw to  
8 secure another implant structural member therein. The  
9 closure has a cylindrical plug, base or body. A non-  
10 circular multi-surfaced bore or aperture extends axially  
11 through or partly through the body and is accessible from a  
12 trailing surface of the body to form a structure or  
13 mechanism for engagement by an installation and/or removal  
14 tool of similar cross section to install or remove the body  
15 from the bone screw, if necessary. As used herein, the term  
16 multi-surfaces is intended to include multi-lobular or any  
17 other horizontal cross section (relative to the drawings)  
18 that is not round and that is adapted to mate with an  
19 insertion tool or removal tool, so as to provide grip or  
20 purchase to the tool while the tool rotates about an axis of  
21 rotation of the closure so as to operably install and set  
22 the closure or alternatively to remove the closure upon  
23 reverse rotation of the tool. In particular, within the  
24 body of the closure, the removal aperture is formed into a



1 non-round multi-surfaced socket to receive a closure removal  
2 tool having a non-round cross sectional shape which is  
3 complementary to the shape of the socket. As noted above,  
4 the socket has a horizontal cross section or footprint that  
5 is non-round so that after a tool of similar cross section  
6 is placed in the aperture, an interference fit is provided  
7 when the tool is rotated, so as to rotate the body.

8       The multi-surfaced socket of the aperture is preferably  
9 formed by a plurality of centrally facing surfaces  
10 positioned circumferentially about a socket axis and  
11 extending generally parallel to the axis that is coaxial  
12 with an axis of rotation of the body. Such surfaces may  
13 include a plurality of planar surfaces, such as or similar  
14 to a hexagonal Allen socket or non-planar surfaces,  
15 including or similar to Torx (trademark of Textron, Inc.) or  
16 other multi-lobular shapes. A multi-lobular shape  
17 preferably includes a plurality of circumferentially spaced,  
18 centrally facing, rounded lobes separated by axial grooves  
19 or channels which receive splines of the closure removal  
20 tool. The splines of the removal tool are circumferentially  
21 spaced and separated by axially extending, rounded,  
22 outwardly facing concave grooves which are shaped to closely  
23 engage the lobes of a matingly shaped closure socket. The  
24 shapes of the closure socket and closure removal tool

1 provide for positive, non-slip engagement of the removal  
2 tool with the closure body while avoiding the localized  
3 concentrations of stresses which can occur with other  
4 configurations of separable torque transfer arrangements.

5       The closure is also provided with a non-threaded guide  
6 and advancement structure for securing the closure in a  
7 receiver and locking the arms against splaying once the  
8 closure is seated in the implant. Preferably, the receiver  
9 is a rod receiving channel of an open-headed bone screw,  
10 hook or other medical implant in which the channel has an  
11 open top and is located between two spaced apart arms  
12 forming the open head of the bone screw.

13       The body of the closure is cylindrical and has an  
14 external guide and advancement flange extending helically  
15 about the body, relative to the body axis of rotation. The  
16 guide and advancement flange preferably has a compound,  
17 anti-splay type of contour which cooperates with  
18 complementary internal mating guide and advancement  
19 structures formed into the inner surfaces of spaced apart  
20 arms forming the open head of the bone implant screw. The  
21 flange has such a compound contour that includes an inward  
22 anti-splay surface component on the flange which faces  
23 generally inward toward the body axis. The mating guide and  
24 advancement structures of the bone screw head have a

1 complementary contour to the body flange including outward  
2 anti-splay surface components which face outward, generally  
3 away from the body axis.

4       The inward anti-splay surface component is preferably  
5 formed by an enlarged region near an outer periphery of the  
6 body flange near a crest of the flange. The outward anti-  
7 splay surface components are formed near an outer periphery  
8 of the mating guide and advancement structures by  
9 enlargement thereof. The complementary anti-splay surface  
10 components of the closure and head slidably engage upon  
11 rotation and cooperate to interlock the body with the arms  
12 so as to resist splaying tendencies of the arms when the  
13 closure is strongly torqued or when other forces are applied  
14 to the various elements thereof.

15       In use, the closure and open-headed bone screw are used  
16 to anchor a spinal fixation member, such as a rod, by  
17 threadedly implanting the bone screw into a bone and  
18 clamping the rod within the head of the bone screw using the  
19 closure body. In order to enhance clamping engagement of  
20 the rod, the body may be provided with structural features  
21 which cut into the surface of the rod to thereby reduce the  
22 likelihood of translational or rotational movement of the  
23 rod relative to the bone screw. The body is preferably  
24 provided with a "cup point", set ring, or V-ring on a

1 forward end of the body to cut into the surface of the rod  
2 when the body is tightly torqued into the head of the bone  
3 screw. In some embodiments, the body is also provided with  
4 a central axial point on the leading end thereof.

5

6 Objects and Advantages of the Invention

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8 Therefore, objects of the present invention include  
9 providing an improved closure for use with an open headed  
10 bone screw; providing such a closure having a cylindrical  
11 base or body that provides a low or minimized profile  
12 subsequent to installation of the closure; providing such a  
13 closure having removal structure enabling positive, non-slip  
14 engagement of the closure by a removal tool; providing such  
15 a closure having an axially extending multi-surfaced  
16 aperture that opens onto the trailing surface of the body  
17 for use in both installing and removing the body; providing  
18 such a closure having such an aperture that forms a removal  
19 tool receiving socket including a plurality of centrally  
20 facing surfaces positioned circumferentially about an axis  
21 of rotation of the body and extending generally along the  
22 axis to form the non-round, non-slip socket to receive a  
23 removal tool having a complementary shape; providing such a  
24 closure which has such a removal aperture with a multi-

1 lobular shape including a plurality of circumferentially  
2 spaced, centrally facing, rounded lobes separated by axial  
3 grooves or channels which receive splines of the removal  
4 tool; providing such a closure in combination with an open  
5 headed bone implant screw for use in anchoring a bone  
6 fixation structural member, such as a rod; providing such a  
7 combination in which the open headed bone screw includes a  
8 pair of spaced apart arms forming a rod receiving channel;  
9 providing such a combination including an external guide and  
10 advancement flange on the closure body and internal mating  
11 guide and advancement structures located on inner surfaces  
12 of the bone screw head which slidably mate upon rotation of  
13 the body and that interlock and cooperate to resist  
14 tendencies of the arms to splay or diverge when the closure  
15 is torqued tightly into clamping engagement with a rod  
16 positioned in the channel or when external forces are  
17 applied to the implant; providing such a combination  
18 including elements to enhance setting engagement of the  
19 closure body with a rod in the bone screw channel; providing  
20 such a combination in which a forward end of the closure  
21 body is provided with an axially aligned point and/or a  
22 peripheral cup point or V-ring to cut into the surface of  
23 the rod when the body is torqued and tightened, to resist  
24 translational and rotational movement of the rod relative to

1 the bone screw; and providing such an anti-splay closure  
2 body with a multi-surface aperture which is economical to  
3 manufacture, which is secure and efficient in use, and which  
4 is particularly well adapted for its intended purpose.

5 Other objects and advantages of this invention will  
6 become apparent from the following description taken in  
7 conjunction with the accompanying drawings wherein are set  
8 forth, by way of illustration and example, certain  
9 embodiments of this invention.

10 The drawings constitute a part of this specification,  
11 include exemplary embodiments of the present invention, and  
12 illustrate various objects and features thereof.

13

14 Brief Description of the Drawings

15

16 Fig. 1 is an enlarged perspective view of an anti-splay  
17 closure with a multi-surfaced removal aperture in accordance  
18 with the present invention.

19 Fig. 2 is a side elevational view of the closure at a  
20 further enlarged scale.

21 Fig. 3 is a top plan view of the closure and  
22 illustrates details of the multi-surfaced aperture of the  
23 closure.

1        Fig. 4 is a bottom plan view of the closure and  
2 illustrates a V-ring on a forward end of the closure.

3        Fig. 5 is a cross sectional view of the closure, taken  
4 on line 5-5 of Fig. 3, and illustrates internal details of  
5 the multi-surfaced aperture of the closure.

6        Fig. 6 is a fragmentary side elevational view at a  
7 reduced scale of the closure in combination with an open  
8 headed bone screw implant in a vertebra with the closure  
9 partially installed in the implant.

10       Fig. 7 is a view similar to Fig. 6 and illustrates full  
11 installation of the closure into the implant.

12       Fig. 8 is an enlarged cross sectional view of the body  
13 of the present invention positioned in clamping relationship  
14 within an open headed bone screw and illustrates details of  
15 an anti-splay guide and advancement structure of the body  
16 and bone screw head.

17       Fig. 9 is an enlarged top plan view of the closure  
18 within the open headed bone screw.

19       Fig. 10 is an enlarged perspective view of a second  
20 embodiment of an anti-splay closure with a multi-surfaced  
21 removal aperture in accordance with the present invention.

22       Fig. 11 is a side elevational view of the second  
23 closure at a further enlarged scale.

1        Fig. 12 is a top plan view of the second closure and  
2 illustrates details of the multi-surfaced aperture of the  
3 closure.

4        Fig. 13 is a bottom plan view of the second closure and  
5 illustrates a V-ring on a forward end of the closure.

6        Fig. 14 is a cross sectional view of the second  
7 closure, taken on line 5-5 of Fig. 3, and illustrates  
8 internal details of the multi-surfaced aperture of the  
9 second closure.

10       Fig. 15 is a fragmentary side elevational view at a  
11 reduced scale of the second closure in combination with an  
12 open headed bone screw implant in a vertebra with the second  
13 closure partially installed in the implant.

14       Fig. 16 is a view similar to Fig. 6 and illustrates  
15 full installation of the second closure into the implant.

16       Fig. 17 is an enlarged cross sectional view of the body  
17 of the second closure positioned in clamping relationship  
18 within an open headed bone screw and illustrates details of  
19 an anti-splay guide and advancement structure of the body  
20 and bone screw head.

21       Fig. 18 is an enlarged top plan view of the closure  
22 within the open headed bone screw.

23

24                    Detailed Description of the Invention



1       As required, detailed embodiments of the present  
2 invention are disclosed herein; however, it is to be  
3 understood that the disclosed embodiments are merely  
4 exemplary of the invention, which may be embodied in various  
5 forms. Therefore, specific structural and functional  
6 details disclosed herein are not to be interpreted as  
7 limiting, but merely as a basis for the claims and as a  
8 representative basis for teaching one skilled in the art to  
9 variously employ the present invention in virtually any  
10 appropriately detailed structure.

11       Referring to the drawings in more detail, the reference  
12 numeral 1 generally designates an anti-splay closure with a  
13 multi-surfaced aperture, such as a multi-lobular or curved  
14 surface aperture 2. The closure 1 generally includes a body  
15 4 that is used in cooperation with an open headed bone  
16 implant screw 8 (Figs. 6 and 7) to form an implant anchor  
17 assembly 9 to secure or anchor a spinal fixation member or  
18 rod 10 with respect to a bone 12, such as a vertebra.

19       The bone screw 8 includes a threaded shank 14 for  
20 threadably implanting into the bone 12 and an open head 16  
21 formed by a pair of spaced apart arms 18 defining a U-shaped  
22 channel 20 therebetween to receive the rod 10. Inner and  
23 facing surfaces of the arms 18 have internal mating grooves  
24 or guide and advancement structures 22 (Fig. 8) tapped, or

1 otherwise formed, therein. The head 16 has tool grip  
2 indentations 23 (Fig. 8) that allow a gripping tool (not  
3 shown) to securely hold the head 16 and facilitate gripping  
4 the bone screw 8 during manipulation for implantation of the  
5 bone screw 8 into the bone 12.

6 The body 4 is cylindrical in external shape about an  
7 axis of rotation 25 (Fig. 7) and has a forward, leading, or  
8 inner end 27 and a rear, trailing, or outer end 28.

9 The body 4 is provided with a guide and advancement  
10 flange 35 which extends helically about the cylindrical  
11 closure body 4. The flange 35 is enlarged near an outer  
12 periphery or radial crest thereof to form a generally  
13 inwardly facing or inward anti-splay surface 37. In a  
14 similar manner, the mating guide and advancement structures  
15 22 are enlarged near the radially outward peripheries  
16 thereof to form generally outwardly facing or outward anti-  
17 splay surfaces 39. The anti-splay or splay resisting  
18 surfaces 37 and 39 mutually engage or slide closely to one  
19 another when the body 4 is rotated and thereby the body 4 is  
20 advanced into the bone screw head 16 so as to interlock  
21 thereby also interlocking the body 4 to the arms 18 to  
22 resist or prevent outward splaying of the arms 18 in  
23 reaction to torque or other forces.

1        Although particular contours of the flange 35 and  
2        mating structures 22 are shown herein, other contours of  
3        anti-splay guide and advancement flanges 35 and mating  
4        structures 22 are foreseen. Examples of such alternative  
5        configurations of anti-splay or splay resisting guide and  
6        advancement flange and mating structures are disclosed in  
7        U.S. Patent application, Serial No. 10/236,123 which is now  
8        U.S. Patent No. \_\_, \_\_, \_\_, and which is incorporated herein  
9        by reference. The flange 35 and structures 22 cooperate to  
10       guide and advance the body 4 into clamping engagement with  
11       the rod 10 within the channel 20 in response to clockwise  
12       rotation of the body 4.

13       In order to more positively secure the rod 10 within  
14       the head 16 of the bone screw 8, the body 4 is provided with  
15       a V-ring or "cup point" 42 on the inner or forward end 27  
16       thereof. The V-ring 42 cuts into the surface of the rod 10  
17       when the body 4 is tightly torqued into the head 16. The V-  
18       ring 42 extends about a periphery of the inner end 27 of the  
19       body 4 and, thus, provides two possible areas of engagement  
20       between the body 4 and the rod 10.

21       In the great majority of cases, the body 4 is torqued  
22       into engagement with the rod 10 in the bone screw 8 and the  
23       anchor assembly 9 is permanently implanted in the bone 12.  
24       However, spinal alignment geometry is complex and it is

1 sometimes necessary to make adjustments to a spinal fixation  
2 system. Additionally, slippage or failure of spinal  
3 fixation components can occur due to injury to the patient,  
4 deterioration of bone tissue, or the like. It is also  
5 possible that an implant system using anchored rods might be  
6 used therapeutically, for example, to set a broken bone, and  
7 subsequently removed. For these reasons, implant anchor  
8 assemblies often provide structures or mechanisms for  
9 releasing an anchor assembly 9 to make such adjustments or  
10 changes in a spinal fixation system. The anchor assembly 9  
11 of the present invention provides the aperture 2 not only  
12 for installation but also for engaging the body 4 to retract  
13 it out of the bone screw head 16 to release the rod 10 to  
14 enable adjustment of the position of the rod 10 relative to  
15 the bone screw 8.

16 In particular, the multi-surfaced aperture 2 is  
17 coaxially positioned relative to the body 4 axis of rotation  
18 25 and provided for non-slip engagement by an insertion tool  
19 and the same or a different closure removal tool (not shown)  
20 having a body with a shape which is complementary to the  
21 shape of the socket formed by the aperture 2 and an  
22 outwardly extending handle, normally of a type  
23 conventionally known as a "torx" driver. The illustrated  
24 aperture 2 is multi-lobular and is formed by a plurality of

1 circumferentially spaced, axially extending lobes 45  
2 separated by intervening spline receiving grooves 47. The  
3 closure installation and removal tool 60 for use with the  
4 aperture 2 has a lower portion with a shape which is  
5 complementary to the socket formed by the aperture 2 and  
6 includes circumferentially spaced splines corresponding to  
7 the grooves 47 and removal and installation tool 60 grooves  
8 corresponding to the lobes 45. The aperture 2 may be of a  
9 Torx type shape which is "hexlobular" or six lobed, or other  
10 multi-lobular shape, such as "penta-lobular" or five lobed,  
11 etc.

12 The axis 25 passes through the aperture 2 so as to  
13 facilitate rotation of the body 4 by a tool having a single  
14 mating projection that conforms to the aperture 2.

15 Illustrated in Figures 10 to 18 is a second embodiment  
16 of an anti-splay closure generally identified by the  
17 referenced numeral 101 with a multi-surfaced aperture 102.  
18 The closure 101 generally includes a body 104 that is used  
19 in cooperation with an open headed bone implant screw 108  
20 (Figs. 15 and 16) to form an implant anchor assembly 109 to  
21 secure or anchor a spinal fixation member or rod 110 with  
22 respect to a bone 112, such as a vertebra.

23 The bone screw 108 includes a threaded shank 114 for  
24 threadably implanting into the bone 112 and an open head 116

1 formed by a pair of spaced apart arms 118 defining a U-  
2 shaped channel 120 therebetween to receive the rod 110.  
3 Inner and facing surfaces of the arms 118 have internal  
4 mating grooves or guide and advancement structures 122 (Fig.  
5 17) tapped, machined by single-point tooling techniques or  
6 otherwise formed, therein. The head 116 has grip  
7 indentations 123 (Fig. 17) to facilitate gripping the bone  
8 screw 108 by an appropriate screw gripping tool (not shown)  
9 during manipulation for implantation of the bone screw 108  
10 into the bone 112.

11 The body 104 is cylindrical in external shape about an  
12 axis of rotation 125 (Fig. 16) and has a forward, leading,  
13 or inner end 127 and a rear, trailing, or outer end 128.

14 The body 104 is provided with a guide and advancement  
15 flange 135 which extends helically about the cylindrical  
16 closure body 104. The flange 135 is enlarged near an outer  
17 periphery or radial crest thereof to form a generally  
18 inwardly facing or inward anti-splay surface 137. In a  
19 similar manner, the mating guide and advancement structures  
20 122 are enlarged near the radially outward peripheries  
21 thereof to form generally outwardly facing or outward anti-  
22 splay surfaces 139. The anti-splay or splay resisting  
23 surfaces 137 and 139 mutually engage when the body 104 is  
24 rotated and advanced into the bone screw head 116, so as to

1 interlock thereby also interlocking the body 104 to the arms  
2 118 to resist outward splaying of the arms 118 in reaction  
3 to torque or other forces subsequently subjected to the  
4 implant.

5       Although particular contours of the flange 135 and  
6 mating structures 122 are shown herein, other contours of  
7 anti-splay guide and advancement flanges 135 and mating  
8 structures 122 are foreseen. Examples of such alternative  
9 configurations of anti-splay or splay resisting guide and  
10 advancement flange and mating structures are disclosed in  
11 U.S. Patent application, Serial No. 10/236,123 which is now  
12 U.S. Patent No. \_\_, \_\_, \_\_, which is incorporated herein by  
13 reference. The flange 135 and or mating structures 122  
14 cooperate to guide and advance the body 104 into clamping  
15 engagement with the rod 10 within the channel 120 in  
16 response to rotation of the body 104.

17       In order to more positively secure the rod 110 within  
18 the head 116 of the bone screw 108, the body 104 is provided  
19 with a V-ring or "cup point" 142 on the inner or forward end  
20 127 thereof. The V-ring 142 cuts into the surface of the  
21 rod 110 when the body 104 is tightly torqued into the head  
22 116. The V-ring 142 extends about a periphery of the inner  
23 end 127 of the body 104 and, thus, provides two possible  
24 areas of engagement between the body 104 and the rod 110.

1 Centrally located relative to the V-ring 142 and coaxially  
2 extending from the body forward end 127 is a point 143 for  
3 penetrating into the rod 110.

4       In the great majority of cases, the body 104 is torqued  
5 into engagement with a rod 110 in a bone screw 108 and the  
6 anchor assembly 109 is thereafter permanently implanted in  
7 the bone 112. However, spinal alignment geometry is  
8 complex, and it is sometimes necessary to make adjustments  
9 to a spinal fixation system. Additionally, slippage or  
10 failure of spinal fixation components can occur due to  
11 injury to the patient, deterioration of bone tissue, or the  
12 like. It is also possible that an implant system using  
13 anchored rods might be used therapeutically, for example, to  
14 set a broken bone, and subsequently removed. For these  
15 reasons, implant anchor assemblies often provide structures  
16 or mechanisms for releasing an anchor assembly 109 to make  
17 such adjustments or changes in a spinal fixation system.  
18 The anchor assembly 109 of the present invention provides  
19 removing the body 104 to retract it out of the bone screw  
20 head 116 so as to release the rod 110 and enable adjustment  
21 of the position of the rod 110 relative to the bone screw  
22 108.

23       In the present embodiment, the removal structure is the  
24 same as the installation structure. In particular, the



1 multi-surfaced aperture 102 is used for both insertion and  
2 removal. The aperture 102 is coaxially positioned relative  
3 to the body 104 axis of rotation 125 and provided for non-  
4 slip engagement by a closure installation and removal tool  
5 160 having a shape which is complementary to the shape of  
6 the aperture 102. The aperture 102 does not fully penetrate  
7 from the rear end 128 to the front end 127, but rather is  
8 spaced therefrom by a wall 144. The illustrated aperture  
9 102 is multi-surfaced and is formed by a plurality of  
10 circumferentially spaced, axially planar surfaces 145 joined  
11 at edges 147. The closure removal tool 160 for engagement  
12 with the aperture 102 has a body with a shape which is  
13 complementary thereto and fits in a hexagonal shaped socket  
14 149 formed by the walls of the aperture 102. The  
15 illustrated aperture 102 has what is normally referred to as  
16 an Allen configuration.

17       It is also foreseen that the multi-surfaced aperture  
18 102 could be of other shapes, such as a multi-faceted shape  
19 having a square, triangular, rectangular, etc. shape.  
20 Alternatively, other non-circular, multi-surfaced shapes are  
21 envisioned for the shape of the aperture 102; however, the  
22 axis 125 passes through the aperture 102 so as to facilitate  
23 rotation of the body 104 by a tool having a single mating  
24 projection that conforms to the aperture socket 149.

1        It is to be understood that while certain forms of the  
2 present invention have been illustrated and described  
3 herein, it is not to be limited to the specific forms or  
4 arrangement of parts described and shown.  
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